SPECIFICATION

SURFACE TREATMENT METHOD FOR LIGHT-METAL CAST PRODUCTS AND VEHICLE ALUMINUM WHEEL TREATED BY THE SAME METHOD

TECHNICAL FIELD

The present invention relates to a surface treatment method for products cast in a light-metal material, and in particular to a surface treatment method for a light-metal cast product obtained by a die-casting process, such as a vehicle wheel made of aluminum or aluminum alloy, or especially for a high-pressure cast light-metal product, and also relates to a light-metal product treated by such a surface treatment method. The surface treatment method is suitable for forming a shiny surface having a superior metal gloss and design quality, over the whole surface or a selected surface portion of the design surface (or the casting surface) of the light metal cast product, through a casting process (hereinafter referred to as a high-pressure casting process) wherein the molten metal of aluminum or aluminum alloy (hereinafter referred to as an aluminum material) is filled in a die cavity, a pressurizing force as high as about 500 kgf/cm^2 to 1100 kgf/cm^2 ($\approx$ 50 megapascal to 110 megapascal) in terms of metal pressure (i.e., pressure applied from the forward end of an ejection plunger to the pressure-receiving surface of the molten metal) is applied by the ejection plunger so as to perform an ejection molding, and optionally, a feeding pressure is exerted and applied to a specific portion of the molten metal during a solidification step thereof by using a pressurizing pin (or a squeeze pin) installed on a die.

PRIOR ART

A cast product made of a light metal material, especially of an aluminum material, such as an aluminum wheel, is a high strength component, and also is a

commodity requiring gloss and a design quality. In the case of a vehicle wheel, many users currently tend towards a preference for an aluminum material having a metal gloss on a design surface. On the other hand, a cast product of an aluminum material is normally cast by a medium or low-pressure casting process using a pressure range (about 0.01 megapascal to 0.050 megapascal, for the low-pressure casting process) lower than the pressure used in the high-pressure casting process described above, which results in many pinholes, some of which are large and form deep recesses. Various surface treatment methods for treating the cast aluminum wheel to produce a shiny surface have been studied, and typically, the following three methods are adopted:

(a) a method in which the casting surface forming the design surface of the cast aluminum wheel is polished by a buffing process, or is buffed and thereafter coated with a transparent coat;

(b) a method in which the casting surface forming the design surface of the cast aluminum wheel is polished and coated with wet-type nickel and chromium platings;

(c) a method in which the casting surface forming the design surface of the cast aluminum wheel is coated with a resin coating layer, and a dry-type plating layer is formed thereon and thereafter coated with a transparent coat.

Among these methods, the method (a) poses the problem that it is difficult to buff the recesses in the casting surface. Consequently, small openings remain unfilled in the design surface. Especially, in the case of a wheel having a design difficult to buff, a sufficient shine may not be achieved.

In method (b), on the other hand, large pinholes, if any, cause insufficient adherence of the chrome plating on the surface which has been polished by a mechanical grinding but has not been machined or was insufficiently machined. These portions easily develop separation of or

corrosion under the plating layer. In order to improve these points, many methods for producing a surface capable of being plated with chromium are used in current general plating processes, wherein, as described in, e.g., Japanese Unexamined Patent Publications (Kokai) No. 6-293974 and 6-2939993, the design surface of a cast aluminum wheel is treated, as a chromate treatment, with chromic acid or shot-blasting so as to close the pinholes formed in the cast aluminum wheel. In this case, however, recycling of the wheel may be difficult. Specifically, in the case where a recycle dealer is entrusted to recycle the plated wheel, separation of chromium or nickel from an aluminum alloy is very expensive. Also in the case where the aluminum wheel is melted in a factory, a large amount of nickel and chromium plated on the surface thereof are mixed with the aluminum alloy as impurities. It is impossible, therefore, to melt the plated wheel products alone. So, it is required to perform the melting process together with an ingot (which contains nickel and chromium at not more than a specified amount). This poses another problem that a many wheels cannot be recycled at one time.

For the reasons mentioned above, the method (c) has been developed and was recently commercialized. The known technique relating to the method (c) is described in Japanese Examined Patent Publication (Kokoku) No. 6-73937. According to this technique, the surface treatment is accomplished as follows:

(1) the surface of a metal material is shot-blasted and thereafter is coated with a powder to provide a primer coat;

(2) a transparent undercoat is applied as an intermediate layer on the powder coating;

(3) chromium is sputtered on the undercoat;

(4) a transparent top coat is applied on the sputtering layer.

This method is superior in that a shiny surface can be obtained without the polishing process which is indispensable for the methods (a) and (b).

On the other hand, to obtain a design surface having a metal gloss superior in design quality, the roughness of the shot-blasted surface must be smoothed out by powder coating. The shot-blasting process forms an unevenness, at least on the order of several tens of μm, on the surface of material. Therefore, the powder coating having the thickness of at least 100 μm is required to smooth the unevenness. Especially in the case where the surface gloss is important and it is required to completely eliminate the unevenness on the surface after powder coating, a thickness of not less than 150 μm is required.

In another surface treatment method, disclosed in Japanese Unexamined Patent Publication (Kokai) No. 6-227201, the design surface, of an aluminum wheel obtained by casting, is treated by a primer coat, thereafter is sputtered with aluminum, and the surface thereof is protected by a transparent coat. In this way, the aforementioned disadvantage which otherwise might result from the dry-type plating layer is obviated.

However, pinholes cannot be completely closed up, even by the method disclosed in the Kokai No. 6-227201. Consequently, the gas contained in the pinholes may expand or break the coating during a baking finish process of the prime coat wherein the temperature of the aluminum wheel is increased about 150°C, which causes a problem in that pits are formed on the surface of the sputtering layer and thereby a satisfactory design quality cannot be produced.

On the other hand, the technique disclosed in Japanese Unexamined Patent Publication (Kokai) No. 9-290213 is constituted as described below. First, the surface of the metal material is degreased and washed in

water. Then, at least one layer of "a colored base coat" and "a colored or transparent resin" is applied. The surface thereof is covered with "a sputtering film", and a transparent "top coat" is applied thereon. In the embodiment disclosed in the Kokai No. 9-290213, the thickness of the "colored base coat" is 10 to 30 μm, and a powder coating layer of 60 to 150 μm is applied thereon. Therefore, the thickness of the prime layer including the "sputtering film" is about 70 to 180 μm.

However, the powder coating, being thicker than the normal thickness, applied before the dry-type plating process has posed problems as follows:

·the thicker the prime resin layer for leveling to remove the unevenness caused in the shot-blasting process, the larger the deterioration of an antichipping characteristic, so that a satisfactory result cannot be obtained in an acceptability determining test conducted by a predetermined method;

·the cost is increased due to the thicker powder coating;

·even if a very hard dry-type plating is applied, a high surface hardness cannot be provided as the thickness of the resin layer increases, because the resin layer constituting the prime coat of the dry-type plating is so soft that the thicker the resin layer, the more significantly the surface hardness is affected.

In recent aluminum wheels for vehicles, to meet the demand for an improved strength, by increasing the internal density of the casting, the die casting is sometimes conducted, for forming a cast product of an aluminum material, by setting the casting pressure in a high range rather than in a low or middle range. In the case of the aluminum wheel formed under a pressurizing force in such a high range, however, a release agent coated on the die may not be sufficiently removed from the surface of the metal material by "the degreasing and

washing in water" after the casting process. In other words, the release agent tends to be strongly attached to the surface of the metal material during the casting process, and thus cannot be easily removed.

On the other hand, even when the casting pressure is set to a high pressure range, it is generally considered difficult to completely eliminate the generation of pinholes from the surface of the cast aluminum product. In order to remove the release agent and to close the remaining pinholes, the surface of the material is usually cleaned by use of a comparatively inexpensive shot-blasting process. Specifically, in order to conduct the surface treatment of cast aluminum products formed in high pressure range by the method described in the Kokai No. 9-290213, the shot-blasting process is executed. Therefore, even in the casting process in the high pressure range, the thickness of the prime layer of the sputter film is required to be not less than 100 μm, or in some cases, not less than 150 μm. This unavoidably deteriorates the chipping characteristic as described above, and the cast product cannot pass a final test for determining the acceptability.

DISCLOSURE OF THE INVENTION

In view of the above-mentioned problems of the prior art, the main object of the present invention is to provide a surface treatment method, for a light-metal casting, in which the internal strength and the casting surface of an aluminum casting have predetermined high qualities, before the surface treatment is conducted, by selecting the casting condition of the light-metal material, especially of the aluminum material, so that the subsequent surface treatment step can produce a shiny surface superior in metal gloss and design quality and a superior chipping characteristic, and also to provide an aluminum cast product subjected to such a surface treatment method.

Another object of the invention is to provide a surface treatment method for a light-metal cast product, obtained by a high-pressure casting process from a light-metal material such as an aluminum material, on which a dry-type plating is coated so as to produce a metal gloss, wherein the thickness of the priming resin under the dry-type plating film is reduced to a range between 10 μm and 40 μm, which is thinner than the conventional priming resin, and thereby realizing a metal gloss superior in design quality.

Still another object of the invention is to provide a surface treatment method and an aluminum cast product, especially an aluminum wheel, subjected to the surface treatment method, wherein the casting surface of the light-metal casting, which is obtained through a high-pressure casting process capable of remarkably reducing the number and size of pinholes generated during the casting process, is subjected to a direct polishing process so as to remove the pinholes on the casting surface to form a smooth polished surface, without performing shot-blasting or a chromate treatment with chromic acid, so that a uniform and thin resin coating layer is attached as an undercoat, and wherein a dry-type plating layer of the desired metal such as aluminum is formed to produce a design surface superior in shininess and gloss and capable of passing an acceptability determination test for a chipping characteristic conducted according to a predetermined procedure.

In order to achieve the above objects, the present invention adopts a polishing process, especially, a barrel finishing process on the casting surface of a light-metal casting, in place of the conventional shot-blasting process. After the barrel finishing process, the first resin coating is applied as a primer of a dry-type plating. The barrel finishing is a method of polishing in a dry condition by using a mixture, called a medium, of a powder material and an abrasive. After the

barrel finishing process, the first resin coating layer having a thickness not less than 10 μm and not more than 40 μm is formed on the polished surface, and further a dry-type plating layer is formed on the surface of the first resin coating layer. The dry-type plating is for forming a predetermined metal coating layer by a sputtering process, and, in the case where the dry-type plating layer is soft, a topcoat layer is formed of a transparent second resin coating on the dry-type plating layer.

The applicable polishing process can include a buff polishing process or a liquid honing process, instead of the barrel finishing process. The buff polishing process is one in which an abrasive is held in a buff made of a soft material such as a cloth and the buff is rotated while being abutted against a workpiece to polish it. The abrasive used in this process is fixed by an adhesive on the outer peripheral surface of the buff or is mixed with a medium such as water to be sprayed on the buff. The liquid honing process is a method in which a polishing liquid is injected from a nozzle to a workpiece to polish it. The polishing liquid is generally a mixture of water and alumina or white alundum, etc. The barrel finishing process has the advantage, as compared with the buff polishing process, that the polishing process can be completed within a shorter time and mass treatment can be performed to reduce a polishing cost. Also, as compared with the liquid honing process, a mirror polished surface can be advantageously obtained and the thickness of the prime resin for smoothing the polishing surface can be advantageously reduced.

In the case of a casting produced by a low-pressure casting method or a weight casting method, the application of the resin coating to the barrel-polished surface makes parts of the coating surface bubble as small as a sesame seed or an azuki bean. These bulges

are generated as the gas in the many pinholes on the polished surface is expanded by the heat treatment during the painting process. In the conventional shot-blasting process, many pinholes are crushed by shot particles colliding under high pressure, and therefore the problem of bulges rarely occurs. In the barrel finishing process, however, most pinholes remain uncrushed.

The dry-type plating on the coating surface may also pose a problem. Specifically, an attempt to increase the vacuum degree in a chamber accommodating a casting for a dry-type plating often fails as gas in the pinholes leaks out through the resin coating film. The thin resin coating according to this invention further facilitates the passage of the gas through the resin coating film and a longer time is required before the vacuum degree is increased.

Therefore, it is readily comprehended that, in an aluminum wheel cast by the low-pressure casting process, a metal gloss superior in design quality cannot be easily obtained by "applying the resin coating after barrel polishing and also applying the dry-type plating thereon".

The present inventors have discovered that a high-pressure casting process can sufficiently reduce the number of pinholes and the dimension of the opening of the latter (i.e., a pinhole size) on the casting surface, and that the above-described surface treatment method can be successfully accomplished. It has also been found that a casting surface having a metal gloss superior in design quality can be obtained by performing the above-described surface treatment method on the casting obtained by the high-pressure casting process as already described. In the case where the pressure cannot be easily transmitted under such conditions that "the sectional area of the gate is small", however, the pressure of the ejection plunger fails to be sufficiently transmitted to the casting surface far from the gate, and

pinholes still remain unclosed. Therefore, it is difficult to obtain a surface having a metal gloss superior in design quality.

In view of this, the present inventors have conducted a casting test "under such a die condition for an aluminum wheel that a pressurizing pin is arranged in opposed relation to a die gate to pressurize simultaneously with a solidification and contraction". As a result, it was found that the pressure is sufficiently transmitted to the design surface of the casting so that the above surface treatment method can produce a metal gloss superior in design quality. Thus the problem mentioned above was solved.

According to the present invention, there is provided a surface treatment method for a light-metal casting, comprising:

a casting step for applying a casting pressure of more than about 50 megapascal from an ejection plunger to a molten metal of a light-metal material poured into a die, to form a casting having pinholes generated in a casting surface, the pinholes being suppressed so as to meet a predetermined condition;

a polishing step for reducing a surface roughness of a polished surface obtained by polishing the casting surface to not more than a predetermined value;

a painting step of forming a first resin coating layer on the polished surface; and

a plating step for forming a layer of a metal or a metal compound through a dry-type plating on a surface of the resin coating layer.

Preferably, the predetermined condition of the pinholes generated on the polished surface is that the number and a maximum opening dimension of the pinholes generated in a predetermined area of the polished surface is not more than a predetermined value. Especially, it is preferred that the number of the pinholes is 1 to 15 per 100 cm^2 of the polished surface and the maximum

opening dimension is not more than 2 mm. More preferably, the number of the pinholes is in the range of 1 to 10 per 100 cm^2 of the polished surface, the maximum opening dimension is not more than 2 mm and the number of the pinholes having the maximum opening dimension of 1.0 to 2.0 mm is one or zero.

Preferably, the surface roughness of the polished surface obtained by the polishing process is 6.3 μm in Rmax.

Preferably, the thickness of the first resin coating layer is not less than 10 μm and not more than 40 μm, and a transparent second resin coating layer is formed as a top coat layer on the dry-type plating layer of a metal or a metal compound.

Preferably, the casting step includes a pressurizing step for applying a squeeze pressure by a pressurizing pin to a predetermined portion of the molten metal of the light-metal material filled in a die cavity during a solidification process of the molten metal under a high pressure.

According to this invention, there is provided a shiny aluminum vehicle wheel, characterized in that the aluminum wheel is cast by a high-pressure casting process, in which a molten metal of an aluminum material filled in the cavity of a vehicle wheel casting die is pressurized by an ejection plunger and, in a solidification process of the molten metal, a portion of the molten metal corresponding to a formed wheel boss is pressurized by a pressurizing pin arranged in the die, so that pinholes generated in a casting surface of an aluminum casting have a dimension of not more than 1.0 mm diameter and the number is not more than 10 per 100 cm^2 area; and that the aluminum wheel comprises a structure wherein the casting surface is a barrel-polished surface with a roughness Rmax of not more than 1.6 μm, a resin coating layer with a thickness of not less than 10 μm and

not more than 40 μm is formed as an undercoat on the barrel-polished surface, a dry-type plating layer made of a metal or a metal compound is formed on the resin coating layer and a transparent topcoat layer is formed on the dry-type plating layer so as to provide a design surface.

In the surface treatment method for the light-metal casting having the aforementioned structure, an aluminum wheel made by a high-pressure casting process is polished so that the surface of the aluminum wheel is polished almost to a mirror-surface although slight polishing scars remain thereon. Thus, the mirror-surface treatment of the aluminum wheel surface is made possible by forming a resin coating layer thinner than that in the shot-blasting process. Especially, the barrel finishing process can provide a mirror surface of the aluminum wheel with a resin coating layer as thin as not less than 10 μm and not more than 40 μm, which is remarkably thinner than that in the shot-blasting process.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of this invention will be made apparent by the description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a flowchart illustrating a cast body producing process and a surface treatment process for a light-metal cast product according to an embodiment of the present invention;

Fig. 2 is a sectional view of essential parts, schematically showing a construction of a high pressure casting apparatus for casting a light-metal casting under a high pressure;

Fig. 3 is a sectional view schematically showing a high pressure casting apparatus wherein a pressurizing pin operating mechanism is omitted, as a modification of the high pressure casting apparatus shown in Fig. 2;

Fig. 4 is a sectional view schematically showing a construction of a barrel finishing machine used for carrying out the surface treatment method according to this invention;

Fig. 5 is a sectional view showing an example structure of an aluminum wheel which is cast by the high pressure casting method and treated by the surface treatment method according to the invention;

Fig. 6A is an enlarged sectional view showing the surface treated state of portion "A" of the aluminum wheel shown in Fig. 5;

Fig. 6B is an enlarged section view similar to Fig. 6A, showing a light-metal cast product treated by a conventional surface treatment method;

Fig. 7 is a perspective view schematically showing a construction of a test device for testing the antichipping performance of a light-metal cast product subjected to a surface treatment;

Fig. 8 is a diagram showing a part of the surface portion indicating the result of an antichipping performance test conducted after a cast aluminum wheel made by the conventional middle or low pressure casting method is treated by the conventional surface treatment method; and

Fig. 9 is a diagram showing a part of the surface portion indicating the result of an antichipping performance test conducted on an aluminum wheel which is cast by the high pressure casting method and treated by the surface treatment method according to this invention.

BEST MODE FOR CARRYING OUT THE INVENTION

Now, specific embodiments of the invention will be explained in detail with reference to the accompanying drawings.

Referring to the flowchart of Fig. 1 illustrating the process of high pressure casting and surface treatment, according to this invention, an aluminum wheel is first cast by the high pressure casting process (step

100). In this process, a molten metal of an aluminum material is filled in a cavity 14 of a die 12 through an ejection plunger 16 by using a high pressure casting apparatus 10 as shown in Fig. 2, and a high pressure of about 50 megapascal to 110 megapascal is applied to the molten metal in the cavity 14 from the front end surface of the ejection plunger 16. A most preferable embodiment comprises a pressurizing pin 20 in opposed relation to a gate 18 of the die 12. In the solidification process of the molten metal, simultaneously with the pressurizing step of the molten metal filled in the die cavity 14 by the ejection plunger 16, the pressurizing pin 20 pressurizes, due to the operation of a hydraulic cylinder 22, a portion of the molten metal opposed to the gate 18. As a result, the pressure of the ejection plunger 16 is sufficiently transmitted to a casting surface area far from the gate 18. Thus, pinholes can be prevented from existing in the casting surface after the casting process is completed, and a density improvement after solidification can be facilitated. The operation of the pressurizing pin 20 may be controlled in such a manner as to apply a pressurizing force in accordance with a desired pressure curve (i.e., a curve of time vs. pressure) from an optimum timing by a changeover four-way valve 24. Because the generation of pinholes on the casting surface can be sufficiently reduced by the above described high pressure casting process as compared with the low-pressure or medium-pressure casting process, without operating the pressurizing pin 20, it can be seen that the functions and effects of the present invention can be achieved by the surface treatment method, described below, performed on a light-metal casting, such as an aluminum material, cast through a high pressure casting apparatus (see Fig. 3) with no pressure pin 20. Referring again to the flowchart of Fig. 1, the aluminum wheel cast body removed from the die 12, after the high pressure casting is completed, is treated in a desired

heat treatment step (step 105), and a machining step, such as a machining of the rim thereof, is performed in accordance with the dimensions and profile of a vehicle wheel (step 106). The aluminum wheel cast body thus subjected to the machining step is designated by, e.g. a reference numeral 26 in Fig. 4, and the casting surface thereof is then subjected to a barrel finishing step as shown in Fig. 4 (step 110).

In the barrel finishing step, the aluminum wheel cast body 26 is mounted on the barrel finishing machine 28. First, medium 30 comprising a mixture of corn or cork and abrasives is charged into a barrel bath 32. The aluminum wheel cast body 26 fixed on a disk connected to a motor shaft is inserted into the medium 30 in the barrel bath 32. In this condition, a motor M1 is started, and the rotational motion indicated by an arrow is transmitted through the disk 34, so that the aluminum wheel cast body 26 rotates in the medium 30 and the medium 30 collides with the surface of the aluminum wheel cast body 26, so as to polish the casting surface of the cast body 26 into a fine surface condition. In the barrel finishing step, a motor M2 is used in the case where the aluminum wheel cast body 26 is to be lowered and positioned within the abrasive in the barrel bath 32.

The aluminum wheel cast body 26, after passing through the barrel finishing step, is taken out from the barrel bath 32 of the barrel finishing machine 28, and is cleaned and degreased through a degreasing step by an appropriate cleaning agent such as water (step 112). Further, the cast body is subjected to the normal chromate treatment for improving the adhesiveness between the casting surface and the coating layer (step 114).

The aluminum wheel cast body 26, after the chromate treatment is completed, is dried in a drying step (step 116), and thereafter is subjected to a primer coating step using resin paint, i.e. an undercoating step (step 120). In this undercoating step, an overlapped coating

layer is preferably formed by the primer coating and the solvent type coating. The primer coating improves a corrosion resistance by using, e.g., an epoxy type resin paint, while the solvent coating improves the adhesiveness of the subsequent dry-type plating by using a polyester type paint and a melamine type solvent paint. In this way, a resin coating layer is formed on the casting surface after being subjected to the barrel finishing, and thereafter the coating layer is baked at 160 °C to 180 °C for 20 minutes (step 130). The thickness of this resin coating layer is selected to be not less than 10 μm and not more than 40 μm.

After the undercoating step, using a resin paint, is completed, the dry-type plating step is effected on the upper surface of the undercoating layer (step 140). As the dry-type plating, three type methods such as sputtering, vacuum evaporation and ion plating are known. Among them, sputtering is most suitably used, because it is superior in film-forming property even for a complicated shape of the design surface of the vehicle aluminum wheel. As the sputtering film, an aluminum film or the like having the thickness of 0.1 μm to 1.0 μm is formed. In the case where a topcoat layer is formed on the sputtering film (step 150), a paint of a urethane type, an acryl type or an epoxy type resin is used and the coating is set to a thickness of about 25 μm to 30 μm. The topcoat layer may be made by using a transparent powder.

The paint of the topcoat layer formed in the manner described above is baked at 100 °C to 160 °C for 20 minutes (step 160).

According to this embodiment, the prime resin coat under the dry-type plating film can have a thickness not less than 10 μm and not more than 40 μm, which is much thinner than the conventional thickness, and an aluminum

wheel product can be finally obtained through a surface treatment for producing a metal gloss superior in design quality.

Fig. 5 is a sectional view showing an aluminum wheel 26a cast by the high pressure casting process and obtained through the surface treatment process described above, which includes a wheel rim 40 on which a tire 50 is mounted, and a wheel hub 42 having, e.g., a central hub hole permitting it to be coupled to a vehicle axle. It should be understood that the sectional shape of the aluminum wheel 42, or especially the sectional shape of the wheel hub 42 is varied from one to another taking the design quality and the strength thereof into consideration, and the shown one is only an example.

Fig. 6A shows and picks out the portion A of the aluminum wheel 26a and is an enlarged view of the surface treatment structure of the design surface of the wheel hub 42. Fig. 6B is a sectional view showing, for comparison with Fig. 6A, a similar aluminum wheel cast body subjected to the surface treatment using a conventional surface treatment method, which cast body is cast by a conventional low-pressure casting method (a molten metal is poured into a die by an application of a low pressure of 0.050 megapascal (about 0.5 kg/cm^2) on the surface of the molten metal).

As is clear from the comparison of the surface treatment structures shown in Figs. 6A and 6B, according to the invention shown in Fig. 6A, because the aluminum wheel cast body 26a is cast by the high pressure casting process, and therefore the casting surface is essentially formed as a smooth surface having a sufficiently reduced number of pinholes, the casting surface can be further buffed or otherwise processed into a still smoother casting surface, and an undercoat layer, a dry-type plating layer and a topcoat layer can be formed in this order by the surface treatment method and, consequently, a design surface of high quality which exhibits the

shininess of a metal film formed as a dry-type plating layer by the sputtering or the like, without unduly increasing the entire thickness of a surface treated layer, can be obtained. In the example shown in Fig. 6A, the topcoat layer is formed of a primer coating and a solvent coating as a preferable typical example. Alternatively, it should be understood that the topcoat layer can be formed of a transparent powder.

In the prior art shown in Fig. 6B, on the other hand, the casting surface of a cast body of an aluminum material formed by the low-pressure casting method is subjected to the shot blasting to close up the pinholes, a thick prime coating layer (with a polyester type powder coating) is formed on the shot-blasted surface to remove the unevenness of the casting surface caused by the shot blasting, an aluminum material film is formed on the smooth surface of the polyester/melamine type solvent coating layer, and an acryl-silicon type solvent coating is applied as a topcoat layer. This construction has a large entire thickness of the surface treated layers, resulting in a deteriorated antichipping performance as described later.

Fig. 7 schematically shows a construction of a test mechanism for conducting an antichipping performance test conventionally used for a quality evaluation test of the design surface of a cast product, especially, a vehicle aluminum wheel, subjected to a required surface treatment on the casting surface of a cast body made of a light-metal material such as aluminum. As shown in Fig. 7, a test piece 60 is arranged above an appropriate screen 70 or on the surface of the screen. A predetermined amount of stones having a predetermined size is injected from a predetermined position by a pressurized air flow in a direction perpendicular to the surface 60A to be tested of the test piece 60, so that the quality of the design surface is evaluated on the basis of the dimension and number of various defects or recesses formed on the

tested surface 60A.

In Fig. 7, a predetermined amount of stones are introduced into a funnel 64 as shown by an arrow S, and an air flow is introduced in predetermined pressure as shown by an arrow R, thereby the injection is performed from an injection pipe 66 as shown by an arrow T. This antichipping performance test is based on the standards of American Society for Testing Materials (ASTMD3170), wherein the acceptability of the quality is determined by visually comparing the defects formed on the tested surface 60A with a certain standard sample surface prepared in advance.

As a condition for the antichipping performance test for a typical vehicle aluminum wheel, basalt No. 6 (4.8 mm to 8.0 mm in diameter) is used as the stones, and the test is conducted by using about 100 grams of the stones at the injection rate of 50 g/sec, the ejection pressure of 4.1 kg/cm^2 (about 0.402 megapascal), with the distance from the test surface being set at 35 cm. In conducting the test, Fly Rock Tester (Model: JA400) made by Suga Shikenki KK (Suita City, Osaka) is used, which is a typical testing device based on the operating principle shown in Fig. 7.

Figs. 8 and 9 show the result of the antichipping performance tests conducted respectively on the design surfaces of the vehicle aluminum wheel produced through the low-pressure casting method and the surface treatment method according to the prior art and of the vehicle aluminum wheel produced by the high-pressure casting method and the surface treatment method according to the invention. It is seen that the wheel of the prior art shown in Fig. 8 has larger chipping defects and a larger number of chipping defects.

In contrast, in the aluminum wheel to be tested according to the invention shown in Fig. 9, it can be seen that the number of chipping defects is remarkably reduced and the dimension of chipping defects is smaller.

In other words, the chipping characteristics of the wheel design surface according to the invention appear to be far superior to that of the prior art.

Referring now to Table 1, the condition of pinholes which remain per 100 cm^2 in portions B1 to B3 on the casting surface (i.e., the casting surface portions corresponding to the wheel portions indicated by arrows B1 to B3 of the aluminum wheel 26A shown in Fig. 5) is listed, wherein two sample cast bodies including a vehicle aluminum wheel cast by the high-pressure casting method with a pressurizing pin according to the invention and a vehicle aluminum wheel cast by the high-pressure casting method alone, and an aluminum wheel cast by the low-pressure casting method according to the prior art, are subjected to the barrel finishing process shown as step 110 in Fig. 1, whereby the respective wheel casting surfaces are finished into one of three removed-material thickness ranges of 40 to 60 μm, of 140 to 160 μm and of 280 to 300 μm.

From Table 1, it is seen that, at each of the portions B1, B2 and B3, the two sample aluminum wheels cast by use of the high-pressure casting process according to the invention (i.e., the high-pressure casting with a pressure pin or the high-pressure casting alone) have a much smaller number of pinholes at all portions on the polished surface than the sample aluminum wheel cast by the conventional low-pressure casting method. Especially, the number of pinholes with large opening dimensions of 1.0 to 2.0 mm diameter appears to be reduced remarkably. Specifically, with the increase in the removed thickness, the high-pressure casting method with squeeze pressure being imparted by the pressure pin appears to form only 15 or less residual pinholes per 100 cm^2 at any wheel portion and a very small number of residual pinholes with large opening dimensions. Accordingly, by treating the high-pressure

cast body of an aluminum material having such a small number of generated pinholes and a small number of large pinholes with the surface treatment process shown in steps 105 to 160 of Fig. 1, a wheel design surface having a very superior antichipping performance, as shown in Fig. 9, can be obtained.

On the other hand, the sample aluminum wheel produced by the low-pressure casting method according to the prior art appears to have a large number of generated pinholes and a large number of larger pinholes, both remaining in the polished surface, even when the removed thickness by barrel finishing is increased. As a result, an aluminum wheel produced by the low-pressure casting method essentially requires crushing of the pinholes by shot-blasting. It is therefore necessary to increase the thickness of the undercoat and to level the undercoat layer on which the metal plating layer is sputtered. This unavoidably deteriorates the antichipping performance of the design surface, as shown in Fig. 8, in the case where a coating layer is superposed as a topcoat layer on the metal plating layer or the like.

As a method of evaluating the coating quality of the design surface of the surface-treated aluminum wheel, various testing methods such as a corrosion resistance test, a weather resistance test, and so on, are generally used and are well known, in addition to the antichipping performance test described above. It has been ascertained that the design surface of a light-metal cast body produced by the surface treatment method according to the invention passes the test provided by the aforementioned evaluation methods.

It will be easily understood by those skilled in the art that the objects, on which the surface treatment method according to the invention is applied, are not limited to an aluminum wheel, but are applicable to other cast bodies of a light-metal material produced through a high-pressure casting process.

Table 1 Condition of pinholes in finished surface

Casting process	Portions	Removed thickness by barrel finishing		
		40 - 60 μm	140 - 160 μm	200 - 300 μm
High-pressure casting + Pressurizing pin	B1	φ0.5 or less: 5 pieces	φ0.5 or less: 3 pieces	φ0.5 or less: 2 pieces φ0.5 - 1.0 : 1 piece
	B2	φ0.5 or less: 4 pieces φ0.5 - 1.0 : 4 pieces	φ0.5 or less: 3 pieces φ0.5 - 1.0 : 1 piece	φ0.5 or less: 5 pieces
	B3	φ0.5 or less: 9 pieces φ0.5 - 1.0 : 2 pieces	φ0.5 or less: 6 pieces φ0.5 - 1.0 : 3 pieces	φ0.5 or less: 3 pieces φ0.5 - 1.0 : 2 pieces
High-pressure casting	B1	φ0.5 or less: 4 pieces	φ0.5 or less: 2 pieces φ0.5 - 1.0 : 2 pieces	φ0.5 or less: 2 pieces
	B2	φ0.5 or less: 7 pieces φ0.5 - 1.0 : 6 pieces	φ0.5 or less: 5 pieces φ0.5 - 1.0 : 5 pieces	φ0.5 or less: 3 pieces φ0.5 - 1.0 : 3 pieces
	B3	φ0.5 or less: 5 pieces φ0.5 - 1.0 : 2 pieces φ1.0 - 2.0 : 1 piece φ2.0 or more: 1 piece	φ0.5 or less: 8 pieces φ0.5 - 1.0 : 6 pieces	φ0.5 or less: 4 pieces φ1.0 - 2.0 : 1 piece
Low-pressure casting	B1	φ0.5 - 1.0 : 2 pieces φ1.0 - 2.0 : 1 piece φ2.0 or more: 3 pieces	φ0.5 or less: 5 pieces φ0.5 - 1.0 : 2 pieces φ2.0 or more: 2 pieces	φ0.5 or less: 2 pieces φ0.5 - 1.0 : 6 pieces φ1.0 - 2.0 : 1 piece
	B2	φ0.5 or less: 5 pieces φ0.5 - 1.0 : 2 pieces φ1.0 - 2.0 : 1 piece φ2.0 or more: 6 pieces	φ0.5 or less: 3 pieces φ0.5 - 1.0 : 12 pieces φ2.0 or more: 1 piece	φ0.5 or less: 6 pieces φ1.0 - 2.0 : 1 piece φ2.0 or more: 2 pieces
	B3	φ0.5 or less: 9 pieces φ0.5 - 1.0 : 2 pieces φ1.0 - 2.0 : 1 piece φ2.0 or more: 4 pieces	φ0.5 or less: 5 pieces φ0.5 - 1.0 : 6 pieces φ2.0 or more: 3 pieces	φ0.5 or less: 4 pieces φ0.5 - 1.0 : 7 pieces φ1.0 - 2.0 : 1 piece φ2.0 or more: 5 pieces

As is apparent from the foregoing description, according to this invention, barrel finishing is carried out on the surface of an aluminum wheel before applying a resin coating of a solvent type as a priming step of a dry-type plating process on the surface of a light-metal material such as an aluminum wheel. Compared with the prior art in which a powder coating layer of not less than 100 μm or in some cases not less than 150 μm is required, the surface can be sufficiently smoothed simply by attaching a resin coating layer of a solvent type in the thickness range of not less than 10 μm and not more than 40 μm, thereby leading to a great advantage that a design surface superior in design properties and antichipping performance, and having a metal gloss, can be obtained at low cost.